

a location of a correlated peak associated with said signature sequence.

### REMARKS

The present application was filed on September 15, 1999 with claims 1 through 30. Claims 1 through 30 are presently pending in the above-identified patent application. Claims 1, 12, and 22 are proposed to be amended herein.

In the Office Action, the Examiner rejected claims 1-3 under 35 U.S.C. §103(a) as being unpatentable over Dejonghe (United States Patent Number 6,363,084) in view of Rakib et al. (United States Patent Number 6,307,868), and further in view of Bohnke (United States Patent Number 6,160,791). Claim 4 was rejected under 35 U.S.C. §103(a) as being unpatentable over Dejonghe in view of Rakib et al., and further in view of Ohkubo et al. (United States Patent Number 6,151,369). Claims 5-10 were rejected under 35 U.S.C. §103(a) as being unpatentable over Dejonghe in view of Rakib et al., and further in view of Klank et al. (United States Patent Number 6,226,337). Claim 11 was rejected under 35 U.S.C. §103(a) as being unpatentable over Dejonghe in view of Rakib et al., and further in view of Van Nee (United States Patent Number 6,404,732). Claims 12-30 were rejected under 35 U.S.C. §103(a) as being unpatentable over Dejonghe in view of Rakib et al., and further in view of Ohkubo, Klank and Van Nee.

The present invention is directed to techniques for estimating the frequency offset and interleaver synchronization in an OFDM communication system. Certain locations in an OFDM frame, such as adjacent bins, are allocated to a signature sequence. Data is differentially encoded in frequency, so that said frequency offset and interleaver synchronization can be estimated from a single OFDM frame. The frequency offset is estimated at a receiver by determining whether a correlated peak associated with said signature sequence is in an expected location. A beginning of an interleaver block is identified based on a location of a correlated peak associated with the signature sequence.

#### Independent Claims 1, 12, 22, 29 and 30

Independent Claims 1-3 were rejected under 35 U.S.C. §103(a) as being unpatentable over Dejonghe in view of Rakib et al., and further in view of Bohnke. The Examiner asserts that

Dejonghe discloses a method for estimating the frequency offset in an OFDM communication system, comprising the steps of: allocating certain locations to a signature sequence (Citing Figs. 1 and 2); transmitting said signature sequence with data to a receiver; and estimating the frequency offset at said receiver by determining whether a correlated peak associated with said signature sequence is in an expected location.

The Examiner further asserts that Bohnke teaches the transmitting and receiving of the power control information in the slot frames of the OFDM system “using a differential method to modulate the data for the power control information (abstract). The information transmitted including the phase reference information (signature sequence) and the power control information (differentially encoded data).”

Applicants acknowledge that Bohnke transmits the power control information using a differential method. The phase reference information, however, which the Examiner compares to the signature sequence of the present invention, is not transmitted using a differential method. Bohnke teaches “one of said subcarriers, for example the first subcarrier in a respective number of subcarriers...carries a phase reference information, if the information is differential phase modulated.” Col. 1, lines 40-44. Thus, if the data being transmitted is differential phase modulated, the phase reference information is transmitted on one of the subcarriers. For example, Figure 1 shows “the first subcarrier shown in said frequency slot is a phase reference subcarrier 1 carrying a phase reference information...(and) the second subcarrier 2 carries a differential encoded power control information.” Col. 1, lines 52-56. Thus, Bohnke does not disclose or suggest “transmitting said signature sequence with data to a receiver wherein said data *and said signature sequence* are encoded using a differential encoding performed in frequency” and does not disclose or suggest “receiving a digital signal, wherein said received digital signal contains a signature sequence in an expected location, wherein said received digital signal is encoded using a differential encoding performed in frequency.”

In addition, as shown in FIGS. 1 and 2, Dejonghe differentially encodes the signal in *time* (vertically in FIG. 1), by comparing corresponding bins (or carriers) of two adjacent frames (or symbols)  $C_0$  and  $C_1$ . Thus, a single frame (or symbol) cannot be decoded at the receiver until the

second frame arrives. In addition, the frequency offset cannot be determined unless multiple frames are received. See, also, mathematical expression 1, at col. 4, line 34, where it is clear that the differential value is  $C_1$  multiplied by the complex conjugate of  $C_0$ .

Each of the independent claims of the present invention emphasize that differential encoding/decoding of the signature sequence is performed in frequency. Therefore, the present invention allows the frequency offset to be estimated from a single frame. In other words, the present invention encodes the data and signature sequence of a single frame differentially across the bins (or subcarriers) in frequency, while Dejonghe encodes data differentially between the bin of one frame and the corresponding bin of another frame.

Thus, Dejonghe does not disclose or suggest “transmitting said signature sequence with data to a receiver wherein said data and signature sequence are encoded using a differential encoding performed in frequency,” as required by independent claims 1 and 22. Similarly, Dejonghe does not disclose or suggest “wherein said received digital signal (that contains a signature sequence in an expected location) is encoded using a differential encoding performed in frequency,” as required by independent claims 12, 29 and 30.

#### Additional Cited References

Rakib has been cited by the Examiner for its disclosure of details on an interleaver. Rakib does not disclose or suggest techniques for estimating the frequency offset or interleaver synchronization in an OFDM communication system, using differential decoding in frequency.

Ohkubo has been cited by the Examiner for its disclosure of frequency offset correction in an OFDM communication system. Ohkubo does not disclose or suggest techniques for estimating the frequency offset or interleaver synchronization in an OFDM communication system, using differential decoding in frequency.

Klank has been cited by the Examiner for its disclosure of transmitting digital frames using multiple modulated carriers having a given reference frequency pattern. Klank does not disclose or suggest techniques for estimating the frequency offset or interleaver synchronization in an OFDM communication system, using differential decoding in frequency.

Van Nee has been cited by the Examiner for its disclosure of a digital modulation

system that provides enhanced multipath performance using modified orthogonal codes. Van Nee does not disclose or suggest techniques for estimating the frequency offset or interleaver synchronization in an OFDM communication system, using differential decoding in frequency.

Dependent Claims

Dependent Claims 2-11, 13-21 and 23-28 were rejected under 35 U.S.C. §103 as being unpatentable over various combinations of Dejonghe, Rakib et al., Bohnke, Ohkubo, Klank and Van Nee. Claims 2-11, 13-21 and 23-28 are dependent on Claims 1, 12 or 22, and are therefore patentably distinguished over Dejonghe, Rakib et al., Bohnke, Ohkubo, Klank and Van Nee (or any combination thereof) because of their dependency from amended independent Claims 1, 12 or 22 for the reasons set forth above, as well as other elements these claims adds in combination to their base claim.

In view of the foregoing, the invention, as claimed in Claims 1-30, cannot be said to be either taught or suggested by Dejonghe, Rakib et al., Bohnke, Ohkubo, Klank and Van Nee (or any combination thereof). Accordingly, applicants respectfully request that the rejection of the claims under 35 U.S.C. §103 be withdrawn.

All of the pending claims, i.e., claims 1-30, are in condition for allowance and such favorable action is earnestly solicited.

If any outstanding issues remain, or if the Examiner has any further suggestions for expediting allowance of this application, the Examiner is invited to contact the undersigned at the telephone number indicated below.

The Examiner's attention to this matter is appreciated.

Respectfully submitted,



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**VERSION MARKED TO SHOW ALL CHANGES**

5 IN THE CLAIMS:

Please amend the claims as indicated below:

1. (Amended) A method for estimating the frequency offset in an OFDM communication system, comprising the steps of:

10 allocating certain locations in an OFDM frame to a signature sequence;  
transmitting said signature sequence with data to a receiver, wherein said data and  
said signature sequence are [is] encoded using a differential encoding performed in frequency; and  
estimating the frequency offset at said receiver by determining whether a correlated  
peak associated with said signature sequence is in an expected location.

15 2. (Unamended) The method of claim 1, wherein said signature sequence is stored in the  
last column of a block interleaver.

3. (Unamended) The method of claim 1, wherein said signature sequence is transmitted  
20 over a number of bins in upper and lower side bands of the digital signal.

4. (Unamended) The method of claim 1, further comprising the step of correcting said  
estimated frequency offset using feedback techniques.

25 5. (Unamended) The method of claim 1, further comprising the step of correcting said  
estimated frequency offset using forward error correction techniques.

6. (Unamended) The method of claim 1, wherein said signature sequence is transmitted  
every L data frames on each side band, where L is generally the number of OFDM frames that can

fill the interleaver memory.

7. (Unamended) The method of claim 1, wherein said signature sequence is transmitted every time an interleaver memory is full.

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8. (Unamended) The method of claim 1, further comprising the step of delaying the transmission of said signature sequence on one side band from the other side band.

9. (Unamended) The method of claim 1, further comprising the step of maintaining said signature sequence in the center of a search window.

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10. (Unamended) The method of claim 1, wherein the signature sequence is a Barker sequence.

11. (Unamended) The method of claim 1, wherein the signature sequence is a Barker sequence with a very low side-lobe.

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12. (Amended) A method for estimating the frequency offset in an OFDM communication system, comprising the steps of:

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receiving a digital signal, wherein said received digital signal contains a signature sequence in an expected location, wherein said received digital signal is encoded using a differential encoding performed in frequency;

correlating said received digital signal using a filter matched to said signature sequence; and

25

identifying whether a correlated peak associated with said received digital signal is an expected location.

13. (Unamended) The method of claim 12, wherein said signature sequence is stored by a transmitter in the last column of a block interleaver.

14. (Unamended) The method of claim 12, wherein said signature sequence is received over a number of bins in upper and lower side bands of the digital signal.

5 15. (Unamended) The method of claim 12, further comprising the step of correcting said estimated frequency offset using feedback techniques.

16. (Unamended) The method of claim 12, further comprising the step of correcting said estimated frequency offset using forward error correction techniques.

10 17. (Unamended) The method of claim 12, wherein said signature sequence is received every L data frames on each side band, where L is generally the number of OFDM frames that can fill an interleaver memory.

15 18. (Unamended) The method of claim 12, wherein said signature sequence is received every time a de-interleaver memory is full.

19. (Unamended) The method of claim 12, wherein the signature sequence on one side band is delayed from the other side band.

20 20. (Unamended) The method of claim 12, further comprising the step of maintaining said signature sequence in the center of a search window.

21. (Unamended) The method of claim 12, wherein the signature sequence is a Barker  
25 sequence with a very low side-lobe.

22. (Amended) A method for synchronizing interleavers in an OFDM communication system, comprising the steps of:

allocating certain locations in an OFDM frame to a signature sequence;

transmitting said signature sequence with data to a receiver, wherein said data and said signature sequence are [is] encoded using a differential encoding performed in frequency; and

identifying a beginning of an interleaver block based on a location of a correlated  
5 peak associated with said signature sequence.

23. (Unamended) The method of claim 22, wherein said signature sequence is stored in the last column of a block interleaver.

10 24. (Unamended) The method of claim 22, wherein said signature sequence is transmitted over a number of predefined bins in both the upper and lower sides of the digital signal.

25. (Unamended) The method of claim 22, wherein said signature sequence is received every L data frames on each side band, where L is generally the number of OFDM frames that can  
15 fill an interleaver memory.

26. (Unamended) The method of claim 22, wherein said signature sequence is transmitted every time an interleaver memory is full.

20 27. (Unamended) The method of claim 22, further comprising the step of delaying the transmission of said signature sequence on one side band from the other side band.

28. (Unamended) The method of claim 22, wherein the signature sequence is a Barker sequence with a very low side-lobe.

25 29. (Unamended) A receiver in an OFDM communication system for receiving a digital signal containing a signature sequence in an expected location, comprising:

a filter matched to said signature sequence for correlating said received digital signal,



wherein said received digital signal is encoded using a differential encoding performed in frequency;  
and

a frequency offset estimator that identifies whether a correlated peak associated with  
said received digital signal is an expected location.

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30. (Unamended) A receiver in an OFDM communication system, comprising:

means for receiving a digital signal having a signature sequence in certain locations,  
wherein said received digital signal is encoded using a differential encoding performed in frequency;

a filter matched to said signature sequence for correlating said received digital signal;

10 and

an interleaver synchronizer that identifies a beginning of an interleaver block based on  
a location of a correlated peak associated with said signature sequence.